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June 16, 2000

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JUN 16 2000
FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Ms. Magalie Roman Salas
Secretary
Federal Communications Commission
445 12th St., S.W.
Washington, DC 20554

Re: ***Ex Parte* Notification**
ET Docket No. 98-153
Ultra-Wideband

Dear Ms. Salas:

This is to note that on June 15, 2000, Jeff Ross, Rachel Reinhardt and William Beeler of Time Domain Corporation and Phillip Inglis, with whom Time Domain has consulted, and I attended a meeting conducted by the University of Texas Applied Research Laboratories to discuss the test plan that Time Domain has asked the UT:ARL to prepare in connection with UT:ARL's examination of the possible effect of ultra-wideband emissions on Global Positioning Satellite(GPS) system receivers. The representatives from UT:ARL included Miguel Cardoza, Douglas Cummings, and Shane Shepherd. The meeting also included John Reed and Greg Czumak of the Commission's Office of Engineering and Technology. A copy of the slides used by the UT:ARL representatives is enclosed. The same slides had been used in a presentation to the Radio Technical Commission for Aeronautics on June 13. The purpose of the meeting was to solicit comment on the draft plan.

Should any questions arise concerning this matter, please contact me.

Respectfully,

David E. Hilliard

David E. Hilliard
Counsel for Time Domain Corporation

cc (w/ encl.): Messrs. Reed and Czumak

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GPS Receiver Performance in the Presence of UWB Transmissions : A Data Collection Campaign

Center for Ultra-Wideband Research and Engineering (CURE)
Advanced Systems Division
Applied Research Laboratories
The University of Texas at Austin

13 June 2000

Agenda

- Test – What it Is, and What it is Not
- GPS Receiver Interference Test Methodology
- General Testing Procedures
  - GPS Receiver, UWB Transmitter, and GPS Simulator Technologies
  - Phases of the Data Collection Campaign
- Test Plan Risks
- Issues
- Rough Schedule
- Questions

Test – What it Is, and What it is Not

- What it is:
  - The first in what is expected to be many such tests
  - Intended to acquire data valuable to the community as a whole
  - Intended to answer some questions, while opening up the possibility for more
- What it its Not:
  - Intended to provide an Analysis, Conclusions, or Recommendations regarding UWB/GPS compatibility
  - An all-inclusive test
  - The only such testing to be performed

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GPS Receiver Interference Test Methodology

- Purpose: To collect a well calibrated and documented set of GPS and UWB interference test data to allow the GPS community to perform its own analysis and draw its own conclusions
  - Data base to be made available to all interested parties
  - Entire interested community to be allowed the opportunity to make comment and suggestions to the test plan prior to test execution
- Test Methodology: Conduct a data collection campaign using a diverse set of GPS receiver technology in both outdoor radiated and indoor simulated testing
  - Calibration of all GPS, UWB, simulator, and test equipment
  - Minimal post-test data reduction

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General Testing Procedures

- Phase I: Prepare the Test Plan
- Phase II: Acquire and calibrate test equipment and develop automated measurement software
- Phase III: Certify the Ultra Wideband Sources in both conducted and radiated modes at an approved FCC measurement facility
- Phase IV: Determine GPS Receiver characteristics
- Phase V: Make interference measurements
- Phase VI: Model aggregate UWB interference effects
- Phase VII: Prepare Final Test Report

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Types of Tests to be Completed

- Conducted Testing
  - Controlled Laboratory Environment With a Simulator Emulating a "real-world" GPS Constellation
    - Issues: Does not adequately represent effects from antenna, filtering, and front-end amplifiers, multipath effects, or ambient noise effects
- Radiated Testing
  - "Real-World" Testing Scenario in which Receivers are actively tracking the GPS constellation
    - Issues: Local environment may be interpreted as UWB impact. GPS monitoring station at ARL:UT to be used as measure of truth
- Aggregation Testing
  - Attempt to determine the effects from multiple UWB transmitters

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Candidate GPS Receiver Technology

- Candidate receiver selected based on following criteria:
  - Representative of unique GPS class or technology
  - Availability of external antenna input to support simulator testing
  - Availability of raw measurement data output to support post-test analysis by the GPS community

Receiver Type	Company	Model #	Pre Amp	Data Availability	Alternate Antenna	Simulator
Survey	Trimble	4700	yes	All Types	yes	yes
Avionic	Garmin	GPS 150XL	yes 16dB	Possible Not Likely	yes	yes
Survey	Garmin	GPS 25	yes 16dB	All Types	yes	yes
Survey	Allen Osborne	SNR-8000	yes 50dB	All Types	yes	yes
Survey	Ashtech	Z-Sensor	yes	All Types	yes	yes
Commercial	Novatel	OEM-4	yes 26dB	All Types	yes	yes
WASS Avionic	Novatel	Millennium	yes 28dB	All Types	yes	yes
Avionic	BAE Systems	CMA-900	yes			
Avionic	Trimble	8100	yes			

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UWB Transmitters

- Two Types of Ultra Wideband Transmitters
  - Intentional Transmitters
    - ♦ Time Domain's Technology
    - ♦ US Radar's Ground Penetrating Radar
    - ♦ Sensors & Software Ground Penetrating Radar
  - Unintentional Radiators
    - ♦ Digital devices such as Personal Computers

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GPS Simulator

- Global Simulation Systems (GSS) STR4760
  - Capable of simulating a "real-world" GPS constellation
  - Capable of re-creating a given time, day, and GPS constellation
  - Provides both C/A and P(Y) Codes structures (although only C/A-code to be used in this test plan)

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Phase I: Prepare the Test Plan

- Develop and Publish for Comments
  - Desire constructive comments from interested parties
  - All comments will be evaluated for compatibility with goals, time frame, and budget

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Phase II: Calibration of Equipment

- All Equipment in the test setup will be calibrated to the highest possible manufacturer's standards and where possible, will be traceable to NIST
- Calibration data for each piece of test equipment will be provided in the final report
- Cables, power dividers, and attenuators will all be measured prior to the test execution in order to determine exact losses through the test setup

Phase III: Certification of Ultra Wideband Sources

- Ultra Wideband Sources from Time Domain Corporation will be certified at an approved FCC laboratory for compliance to current FCC Part 15 rules

Professional Testing (EMI), Inc.
1601 FM 1460, Suite B
Round Rock, TX 78664

Phase IV: GPS Receivers' Characteristics

- Work with manufacturers to determine the following:
  - Receiver bandwidths
  - Receiver front-end characteristics
    - Gain, Noise Figure, Filtering
- Use wideband noise source to baseline receiver performance

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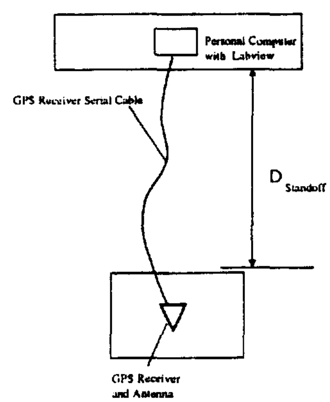
Phase V: Outdoor GPS Baseline Test

- Simplified Block Diagram of Test Setup



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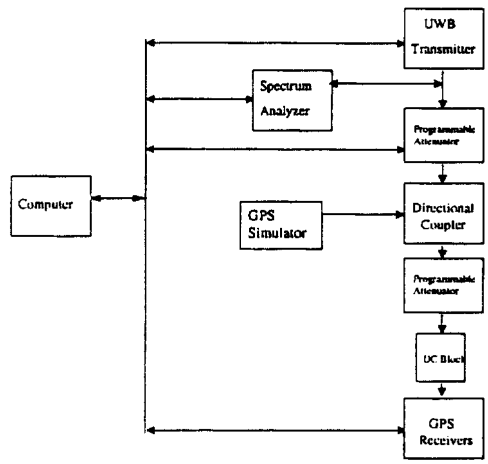
Phase V: Indoor GPS Simulator Test

- Simplified Block Diagram of Test Setup



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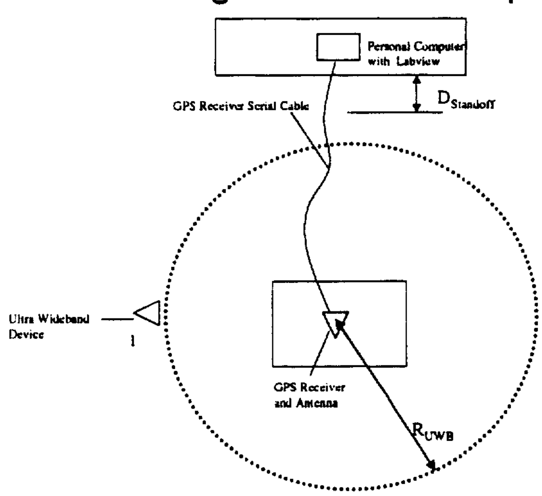
Phase V: Outdoor GPS/UWB Test

- Simplified Block Diagram of Test Setup



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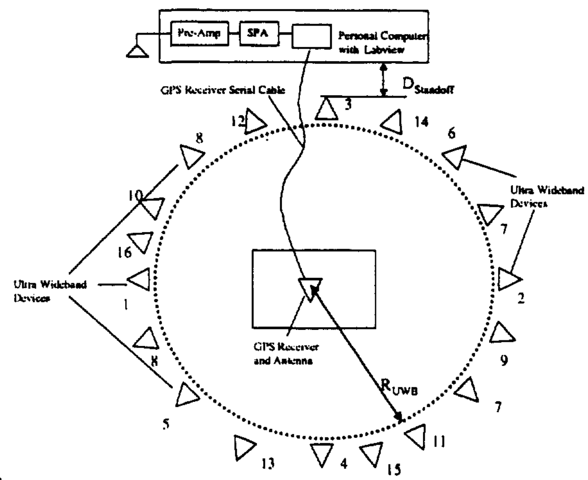
Phase VI: Outdoor GPS/UWB Test - Aggregation

- Simplified Block Diagram of Test Setup



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Phase VII: Prepare Final Test Report

- Will be public information
- Is intended to be filed in response to FCC's NPRM
- Will include only test data
- Will not include analysis or recommendations

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Test Plan Risks

- Timeline
- Amount of data to be collected

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Issues

- Solicitation of input to the test plan from GPS community
  - Extensive use of web-based information dissemination planned
    ⇒http://sgl.arlut.utexas.edu/asd/Cure/index.html
  - Test plan to operate as a "living document" during testing effort to allow for modification to the test procedures as necessary
- Data collection campaign limited to seven (7) representative GPS receivers
  - Required to limit study to within available funding and schedule scope
  - Availability of "loaner" GPS receiver technology may impact schedule
- Availability of high-end test equipment may impact test schedule

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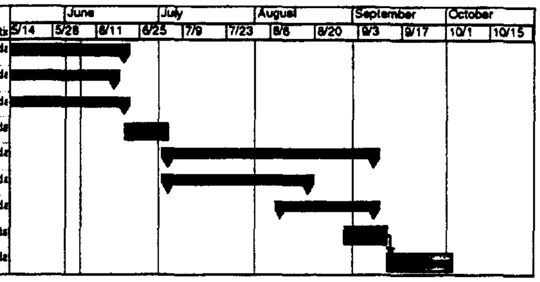
Rough Schedule

ID	Task Name	Durati
2	**Testing Setup**	56 da
3	**Test Plan Development**	55 da
12	**Test Equipment Acquisition and Calib**	56 da
18	Test Setup Integration and Test	10 da
19	**Testing Work**	46 da
20	**Simulator Testing**	33 da
30	**Radiated Testing**	22 da
37	Compile Total Report	10 da
38	Publish Results	15 da



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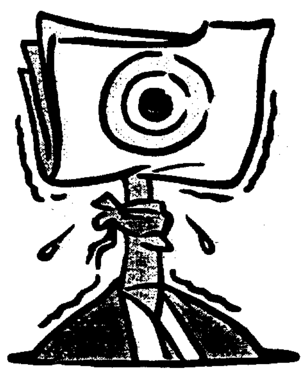
Questions



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Background on UWB Technology

History of Ultra Wideband Technology

- Patent 2,671,896 filed Dec. 18, 1942
- Patent 2,999,128 filed November 14, 1945

Some of the First RF Pulse Communications Systems

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- Patent 3,612,899 filed August 20, 1970
- Patent 3,662,316 filed May 12, 1971

Some of the First Ultra Wideband patents

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- Patent 4,641,317 filed February 3, 1987
- Patent 4,743,906 filed May 10, 1988

Larry Fullerton's first and second Ultra Wideband Impulse Radio Patents

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Background on UWB Technology

Ultra Wideband Definition

- An Ultra Wideband signal has been defined as one with a fractional bandwidth B_f greater than 25% where B_f is defined as:

$$B_f = 2 * \left(\frac{f_H - f_L}{f_H + f_L} \right)$$

where f_H and f_L are the upper and lower 3 dB points of the signal spectrum respectively *

* J. D. Taylor, Introduction to Ultra-Wideband Radar Systems, CRC press, Boca Raton, FL 1995.

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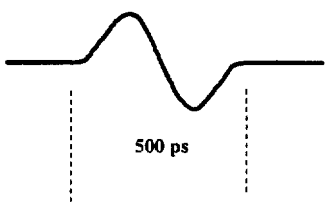
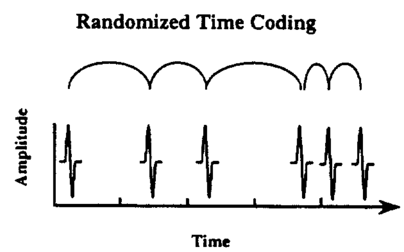
Background on UWB Technology

Definition of Time Domain's Time-Modulated Ultra Wideband Impulse Radio

- Time Modulated Ultra Wideband Impulse Radio does not utilize continuous sine wave as its carrier. It is instead a signal composed of Millions of Gaussian Pulses sent randomly in Time.





Background on UWB Technology

What is a Gaussian Impulse?

The impulse waveforms utilized in Ultra-Wideband Impulse Radio have been likened to the first derivative of the Gaussian function and can be described by the following equation [1]:

$$V = A \cdot \frac{\sqrt{2 \cdot e}}{\tau} \cdot t \cdot e^{\left[\frac{-t^2}{\tau^2}\right]}$$

Where tau is described by the equation: $\tau = \frac{1}{2 \cdot \pi \cdot f_c}$

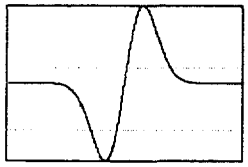
The variable f_c is the center frequency of the transmitted impulse.
This results in an impulse that appears in the time domain as shown on the next page. [2]:

[1] Larry Fullerton, United States Patent Number 5,687,169. United States Patent Office, issued November 11, 1997.
[2] Time Domain Incorporated, Appendix A. Comments of Time Domain Incorporated on ET Docket 98-153, Revision of Part 15 of the FCC's Rules Regarding Ultra-Wideband Transmission Systems. United States of America, Federal Communications Commission, December 7, 1998.

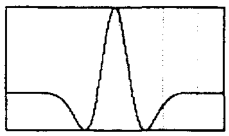
Background on UWB Technology

What is a Gaussian Impulse? Continued

The Gaussian Impulse delivered to the antenna in the time domain *:



The antenna in the system differentiates the waveform and the radiated wave becomes similar to a Gaussian doublet as shown below * .



* Time Domain Incorporated, Appendix A. Comments of Time Domain Incorporated on ET Docket 98-153, Revision of Part 15 of the FCC's Rules Regarding Ultra-Wideband Transmission Systems. United States of America, Federal Communications Commission, December 7, 1998.

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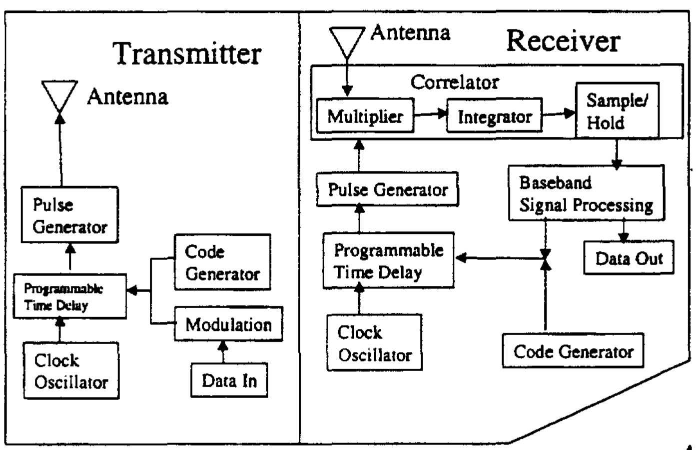
UWB Transmitters

Time Domain Transceiver



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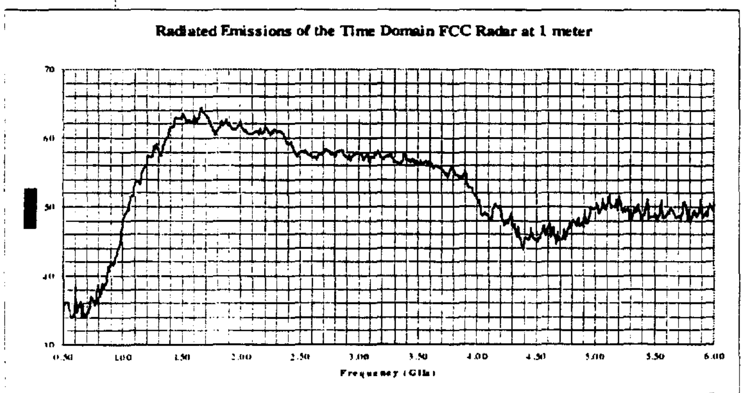
Background on UWB Technology

Radiated Spectrum



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